"HOW CLEAN IS CLEAN?" USING FLUIDJETS AS AN ALTERNATIVE DECONTAMINATION PROCESS FOR MUNITIONS

A continuation of Alliant Techsystem's research on waterjet cutting of explosive ordnance.

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ABSTRACT

Numerous advanced technologies have shown that explosive ordnance can be successfully cleaned of explosives by alternative methods to thermal flashing. As part of Alliant Techsystems continuing research in high-pressure Fluidjets (FJ), we have compared FJ cleaning as an alternative to flashing in order to achieve 5-X decontamination levels.

Background

Alliant Techsystems has independently explored the use of high-pressure fluids for the safe demilitarization of high-explosive filled munitions over the last four years. Several papers presented before the DDESB[1] detail the range of pressures and the safety analyses that Alliant Techsystems has performed to qualify waterjets as a safe and effective method of the cutting and washout of explosive-ladened projectiles and ordnance.

The normal processing procedure for ordnance items that have been loaded with high-explosives is to thermally process (flash) the projectiles after removing the explosive to destroy any trace amount of explosive residue. This process is necessary to prevent residual explosive material from accumulating and causing either an explosive, flammable material or health hazard for people in metal recycling businesses. Thermal processing has certain negative features in that it requires a secondary operation, specialized furnaces, air pollution equipment and significant consumption of fuel to perform properly. Alliant Techsystems has identified that waterjet washout of explosives achieves comparable levels of cleanliness by the removal of the explosive and may save significant time, labor and natural resources if the regulations allow a specific cleanliness level rather than requiring processing in a thermal environment.

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[1]Miller, Paul; Waterjet Papers; Presented at the 25th Dept. of Defense Explosive Safety Board, Aug. 1992. w/ NTSC video "Water- The Cutting Edge".

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Process

Alliant Techsystems is currently operating a pilot high-pressure (50,000 psi) waterjet washout process on 105mm HE loaded shells in the United States and will soon have fully operational facilities for the waterjet washout of Former Soviet Union (FSU) munitions in both Belarus and Ukraine. Projectiles are fed in pairs onto an automatic conveyor and nested into a pair of automatic washout heads for the removal and recovery of the explosive filler. The high-pressure waterjet action is controllable by the programmable sequencer to dwell a sufficient length of time in each type of projectile to completely remove all explosive.

Water from the washout process is used to flush the explosive to the recovery and processing operation. The majority of the water is removed from the explosive and the water is recycled back through the waterjet machine. Of the water that enters the system, 85% of the water is recycled and 15% of the water is lost through evaporation and residual moisture in the reclaimed explosive. The explosive is then removed for conversion into the commercial mining explosive industry.

Waterjet Washout Cleanliness Levels

The use of waterjets for removing tenacious coatings in the aviation industry is well known. Waterjets are commonly used for the removal of the metalized coating on turbine engine parts that resist removal by other methods. Likewise, the use of waterjets for the removal of explosives is extremely efficient at removing all of the material from the ordnance. Alliant Techsystems waterjet washout process for the washout of explosives has demonstrated post-wash residual TNT contamination levels[2] varying from 0.00016 milligrams (0.16 micrograms) per square centimeter to our worst case of 1.6 micrograms per square centimeter. At these levels, there was no visible amount of explosive on the inside of the projectiles, but it was still detectable by advanced analytical instruments. As in any process, the need for statistical process control, such as using simple wipe samples or other analytical techniques, is necessary to monitor and to provide feedback for the control of the process output.

In order to develop a comparison to existing 5-X process, Alliant Techsystems obtained an 81 mm Soviet mortar round that was demilitarized by the U. S. Marine Corps. When chemically analyzed[3] the mortar round contained 2.6 grams of residual TNT. This computes to about 29,400 micrograms per square centimeter. We recently were able to acquire several 90mm projectile[4] half-pieces from the commercial sales scrap metal pile of a U.S. Army

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[2]Hatz, David; Alliant Techsystems Engineering Report Number 9977, Demil Program - Determination of Residual TNT in 105mm Projectile Washed With the Waterjet Washout System, Dated 15 Sept. 1993.

[3]Hatz, David; Alliant Techsystems Engineering Report Number 10030, Demil Program-Russian Mortar Round-Characterization, Dated 19 Nov. 1993.

[4]Webb, Gary; Alliant Techsystems Internal Correspondence to Paul Miller: *Test Subject Rounds for 5-X Decontamination* , 4 May 1994.

ammunition plant. These pieces had originally been filled with Comp B and demilitarized by cutting and having the Comp B pressed out. The shells were then flashed to 5-X in a furnace. The projectiles had been exposed to the weather for several weeks before we acquired them, so we are not able to give highly accurate readings on the items. On one of the projectiles, we were able to identify 31 micrograms per square centimeter of RDX[5] and 37.2 micrograms per square centimeter of TNT for a total of 68.2 micrograms of explosives per square centimeter. These levels are obviously several times what the waterjet washout process is currently reading.

Determination of Necessary Cleanliness Levels

Although no one can say absolutely what the "correct" maximum level is for residual explosives in demilitarized ordnance, other than the elusive "none detectable" level that moves everytime analytical equipment improves. Alliant Techsystems is of the opinion that a good target for controlling the maximum levels of residual explosives is about 75 micrograms per square centimeter (0.5 milligram per square inch). This value was arrived at by analyzing the hazard potential of TNT and RDX being introduced into the scrap metal market and the potential exposure of workers to explosive, flammable material or health hazards.

Given the 75 micrograms per square centimeter density, the film thickness for TNT (d=1.65) is 45 microns and RDX (d=1.82) is 41.2 microns. At these very thin film thicknesses, the projectiles can no longer be reactive as neither TNT nor RDX can burn or deflagrate at layers less than a few millimeters. The published data for common explosive's critical diameter extrapolated to critical thickness is on the order of millimeters, not microns.

As far as the toxicity of the residual explosive material, the allowable quantity of explosive for worker exposure[6] is 1500 micrograms of RDX or 500 micrograms of TNT per cubic meter of respirable air. The vapor pressure of RDX and TNT at ambient temperatures is given[7] as about 6.0 parts per trillion (6.0 ppt) and 7.7 parts per billion (7.7 ppb) respectively. It would be unlikely that workers would be exposed to hazardous or even the allowable levels of explosives from such low vapor pressures.

One final concern was that there were other agency regulations that needed to be addressed in the residual levels of explosives in salvaged ordnance. The principal agency that controls regulations in this case is the Environmental Protection Agency. After careful review, Alliant

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[5]Hatz, David; Alliant Techsystems Engineering Report Number 10164, Determination of Residual Explosives in 90mm Projectiles, Dated 13 May 1994.

[6]American Conference of Governmental and Industrial Hygienists (ACGIH); 1992-1993 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, Cincinnati, OH.

[7]Dionne, B. et al; "Vapor Pressure of Explosives;" Journal of Energetic Materials, Vol. 4, 1986; Pages 447-472.

Techsystems' Safety and Environmental Management specialist advises[8] us that, at these levels of contamination, the empty projectile casings would meet the requirements of the Environmental Protection Agency as being non-hazardous empty containers.

Conclusion

Alliant Techsystems' test data on the washout of high-explosive projectiles by automated high-pressure waterjet systems supports the use of alternative technologies, such as waterjets and CO_2 blast cleaning, in lieu of thermal processing of components contaminated with explosive materials to achieve 5-X decontamination. The benefits derived from using such systems are lower operating costs, less potential for environmental pollution and the ability to adequately clean parts without collateral damage. A recommended level of 75 micrograms per square centimeter (0.5 milligrams per square inch) is given as a suggested level for 5-X decontamination. Data for the most common explosives indicate that at the recommended residual levels no significant explosive, flammable material or health hazards exist.

[8]Pederstuen, Anita; Alliant Techsystems Internal Memorandum to Paul Miller: *Empty Containers* ; 4 Jan 1994.